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Current Dog Breeding Practices Impacts on Health and Preservation of Purebred Dogs

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Dog Breeders and the Future of Dogs

Dogs have walked beside humankind longer than we have had written language to record it. A product of artificial selection, dogs were bred away from the beasts that may have threatened early humans tens of thousands of years ago and into the protector that remains a popular companion today. Dog owners around the world have been increasingly treating their canine companions as members of the family, evident in the increasing legislation regarding animal welfare, appreciation of dogs in popular media, as well as the booming specialty pet products and services industry. As sediments shift from viewing dogs as property to seeing them as family members, more attention has been placed on dog breeding. At the beginning of the 21st century, problems of dog overpopulation, puppy mill exploitation and abuse are brought to light, beginning a movement against dog breeding in order to support rescues and shelters. With dogs becoming ever popular companions, it is hard to imagine a complete phasing out of dog ownership, and the future of dogs is not held by any shelter or rescue. The future of dogs is in the hands of dog breeders.

Each generation of dogs is shaped by individual breeding decisions, which are influenced by the current dog breeding system. The modern system is architected in large part by dog registries such as the Kennel Club (KC) and the American Kennel Club (AKC). The dog registries have an overarching goal to preserve and improve purebred dogs. Each breeder championed by these registries strives to create a better generation of dogs through improved appearance and conformation to a standard, or through increased mental and physical capabilities to perform in dog sports. Dog breeders also strive to maintain a breed and protect its history and heritage. However, these dog registries and breeding standards were created in the 1800's, almost a century before the study of molecular genetics began. The dog breeding and showing doctrines have not significantly changed since. The overall health of dogs has seen declines in the last few decades; shorter lifespans, increased rates of cancers, heart defects and smaller litter sizes have been found with increasing frequency in many breed populations (Farrell, Schoenebeck, Wiener, Clements, & Summers, 2015; Urfer, Gaillard, & Steiger, 2007; Lewis, Wiles, Llewellyn-Zaidi, Evans, & O'Neill, 2018). The current dog breeding system coerces dog breeders into making decisions that could be detrimental to the dogs of the future.

With the recent development of affordable genetic sequencing technologies, huge quantities of genetic population data has become available. This data can give insights to how populations change and how traits including those relating to health are distributed across dog breed populations. Genetic tools both challenge the current dog breeding system and offer an opportunity to better reach the goal set forth in dog breeding: to better the next generation of dogs.

Chapter One: Modern Dog Breeding

A modern dog breed consists of a population of dogs whose pedigrees are tracked by a dog registry. Many purebred dogs can trace their lineage back to the original registered breed founders, with no other breeds or unregistered dogs represented in their lineage. Modern dog breeds do not contain a fully fixed set of characteristics or temperaments. Instead, breed attributes are continuously molded by every breeding choice. Dog breeds change intentionally over time as the desires of dog breeders change. The German Shepherd breed has changed from their foundation in 1899 as German Shepherd breeders began to favor the angulated hind legs that create a sloping back and exaggerated trot in the show ring (Figure 1).

Figure 1: The first German Shepherd Dog registered in 1899, Horand von Grafrath, is pictured on the left. The dog on the right is the 2017 Westminster best-in-show German Shepherd Dog, Rumor (Stephanitz & Schwabacher, 1925; Kearney, 2017).

Dog breeds also change by random chance as hidden genetic traits float through the generations, appearing or disappearing from the population. For instance, degenerative myelopathy (DM), a disease that causes weakness of the hind legs in older dogs, has become prevalent in many breed populations (Figure 2). This trait would not have been internally bred for. Instead, it represents how undesirable traits can become prevalent unintentionally.

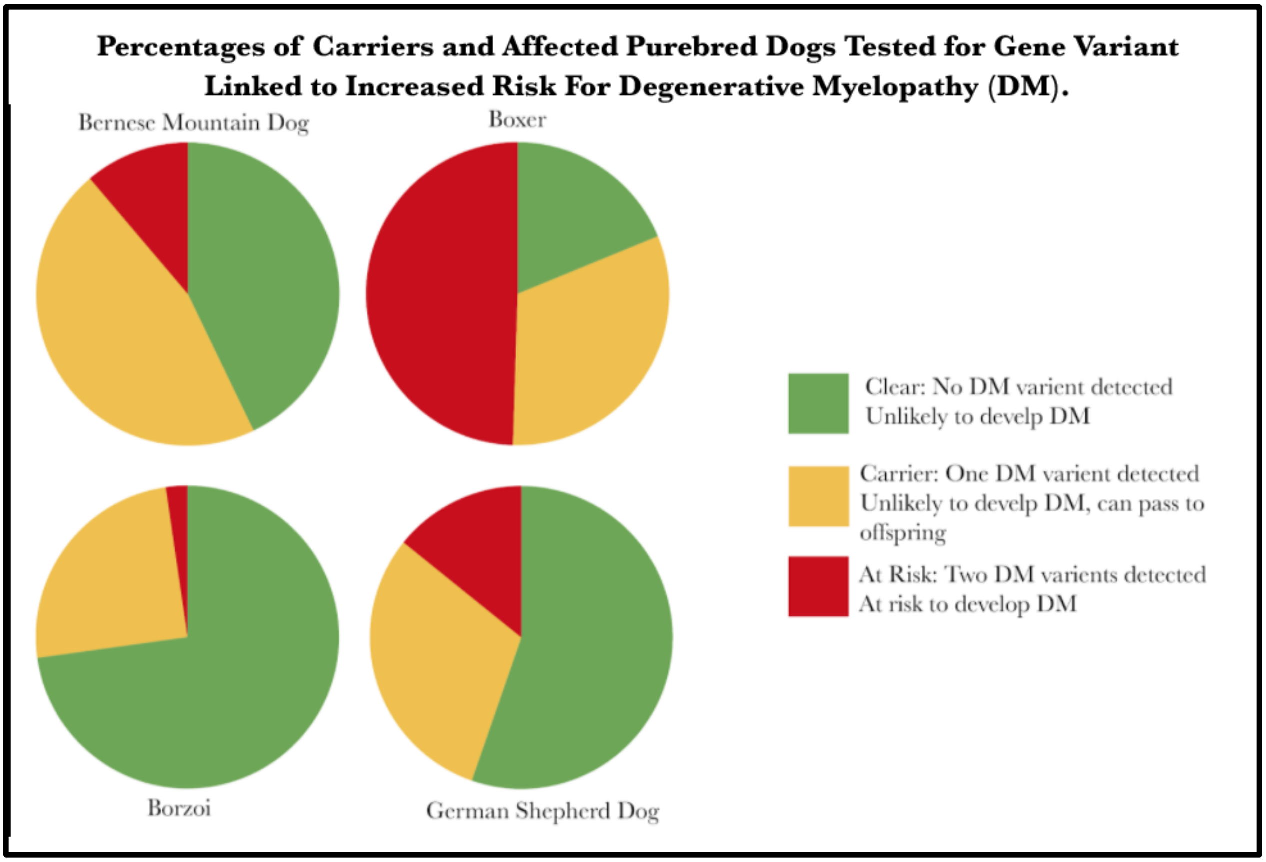


Figure 2: A sample of dog breeds affected by degenerative myelopathy and the percentages of purebred dogs genetically tested to be clear, carriers, or at risk of degenerative myelopathy by The Canine Health Information Center (2020).

Dog breeders who aim to compete in conformation or produce the best working dogs have a goal to improve their breed through making the best pairings. Dog breeders use rigorous testing in the conformation ring or in dog sport competitions, as well as health and temperament testing, to select a handful of dogs deemed fit to create the next generation. Very few dogs contribute to the gene pool, and those who do often contribute heavily (Leroy, 2011). This pattern is also true outside of the professional dog world, with backyard hobby breeders and commercial puppy breeders. Although there is less emphasis on improving the breed through selection in these spheres, there is still a tendency to breed the same individuals multiple times and place the majority of puppies in non-breeding homes.

Dog breeds are strongly rooted in their histories. Many dog breeders can name their favorite historic dogs from a hundred years ago, and list dogs that won historic shows before they were even born, and name kennels that made the biggest impact on the breed today. Even though the histories of dog breeds are valued by dog breeders, modern breeding practices may be dissolving the attributes and contributions of historic dogs. When one individual dog is favored, whether by chance or through merit, the bloodline can become dominant in the breed population and lead to the extinction of other ancestor's contributions. It is not uncommon for a popular stud dog to produce thousands of offspring (Leroy, 2011). Through the overrepresentation of a popular sire in the breed population, a large percentage of the breed become closer relatives. Although the desirable traits of the popular dog will rise in frequency within the breed, any flaws the stud carries in his DNA, hidden or visible, are also propelled in high frequency into the next generation.

Besides what is gained in the population, it is important to consider what can be lost. The populations of many breeds are quite large, with thousands of German Shepherd Dogs and Labrador Retrievers registered with the AKC every year (Miller, 2019). Even though the actual number of individual dogs registered can be quite large, the reduced genetic diversity can cause dog breeds to mimic the genetic behavior of a much smaller population. In order to predict how genetics of populations are expected to change over time, an adjustment can be made from the census population (via counting) to the genetic or effective population. When the effective population becomes small, a phenomenon that can happen when a large population is closely related to one another, genetic drift acts more strongly. Genetic drift is the random fixation of genes through chance, and thus the random extinction of genes from the population. Fixation permanently alters breed characteristics (Soulé, 1996). It wouldn't be likely for a Golden Retriever to be born any other color because the golden color has been "fixed" in the population. Every Golden Retriever has two copies of the gold or "red" gene and each purebred Golden Retriever puppy receives one from each parent, thus they too are red. Fixation can be intentional, as it was for Golden Retrievers, but it can also happen unintentionally.

By the 1970's, every registered Dalmatian tested was confirmed to have abnormally high uric acid, a disease called hyperuricosuria. Hyperuricosuria in Dalmatians was caused by a recessive genetic defect in their uric acid metabolism that had become fixed in the population, much like the red gene had been fixed in Golden Retrievers. High uric acid resulted in many Dalmatians experiencing painful and sometimes deadly urinary tract complications (Safra, Schaible, & Bannasch, 2006). This genetic trait had become fixed in the population due to tight inbreeding, likely for good spot distributions, an important quality in show Dalmatians. The only way to reintroduce the normal gene was to cross a purebred Dalmatian with another breed, a concept blasphemous to the dog registries. However, Dalmatian lover Robert Schaible went ahead with his outcross project, mixing a purebred Dalmatian with a Pointer, and was largely scorned by the dog community. He then bred the Dalmatian cross back to a pure Dalmatian, and contributed to breed his crossed dogs back to Dalmatians until proper type and temperament returned without the harmful mutation. Even though the dogs returned true to type within five generations, the AKC breed club snubbed his carefully bred dogs as mutts and would not give them registration status when he applied in 1980. In 2011, the Dalmatians descending from the pointer cross with healthy uric acid levels were finally registered officially with the AKC (Powell, 2011). During that 30 year time, every AKC Dalmatian was bred to have a painful and sometimes deadly disease for the sake of maintaining purity.

There is good reason to believe that, like a normal copy of the Dalmatian gene, other genes could be going extinct in closed breed populations. These genes could be essential to a breed's temperament, appearance, or health. Popular sires can become overrepresented in the breed and impact the breed population's genetic composition, leading to a surge in the sire's qualities, good and bad. Individual dogs or lines becoming inbred is not necessarily undesirable: inbreeding is a valuable tool to increase the occurrence of favorable traits or remove unwanted traits. However, when an entire breed becomes closely related to every other member of the breed, inbreeding can become detrimental to the health and character of the breed. Inbreeding can lead to the loss of genetic diversity, the amount of genetic variations found within a population or breed. A breeder's ability to select for better traits is dependent on existing genetic variation, which may be increasingly limiting in a closed population. Once an undesirable trait becomes fixed in the breed population, outcrossing to a dog without that trait becomes the only option to correct it, like with LUA Dalmatians. Maintaining genetic diversity is one method to avoid fixation of undesirable traits; if there had been a healthy Dalmatian in the breed population, this dog could have repaired the genetic flaw without need for a pointer mixed breeding.

Current breeding practices often work to decrease a breed's genetic diversity, which has a profound impact on both the individual dog's genome and the breed's population structure as a whole. With recent developments in veterinary science and genetic testing, dog breeders have been increasing emphasis on health testing. X-rays are used to detect abnormalities in hips and elbows, DNA tests are used for screening for harmful recessive mutations, and a myriad of other breed-specific examinations are often considered essential for an animal to reproduce. This strategy of selectively breeding for health has come about due to the observations that dogs, especially large breed dogs, are living short and unhealthy lives (Urfer, Gaillard, & Steiger, 2007). In order to selectively breed for a trait, breeders have to be able to measure it, and health testing is one way to try and measure the health of young breeding animals unlikely to show ailments that could cripple them or their offspring later in life. The selection method has been used with limited success, perhaps due to slow adaptation of the methods or the unreliability of current health tests, which are frequently misunderstood by dog breeders (Farrell, Schoenebeck, Wiener, Clements, & Summers, 2015). There are also many environmental factors that can affect results (Sallander, Hedhammar, & Trogen, 2006).

There is reason to consider that increased selection, even in the pretense of breeding for health, within a tightly related population can cause health problems to arise faster than they can be measured and bred out. Inbreeding is often quantified using the Coefficient of Inbreeding, abbreviated COI. COI is measured from 0%-100%, with 0% COI representing the result of an unrelated pairing. A mating between offspring and parent or the mating of full siblings results in a COI of 25%. Inbreeding depression, the negative effects on overall health and fertility due to high COI of individuals or populations, has been observed at levels of 5% COI and increases at 10% (Allenderorf & Luikart, 2007). Many purebred dogs have inbreeding levels of more than 30% (Figure 3).

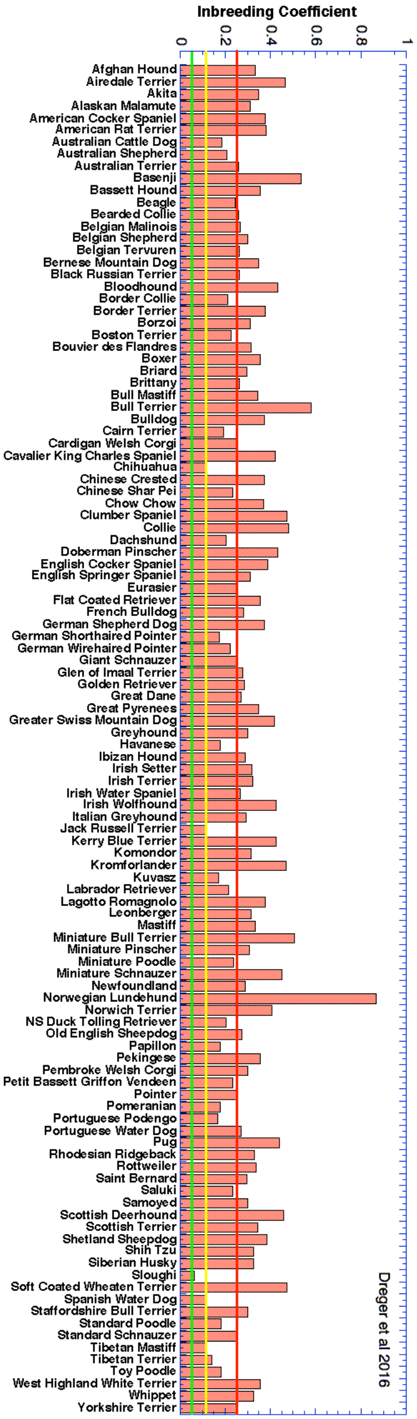
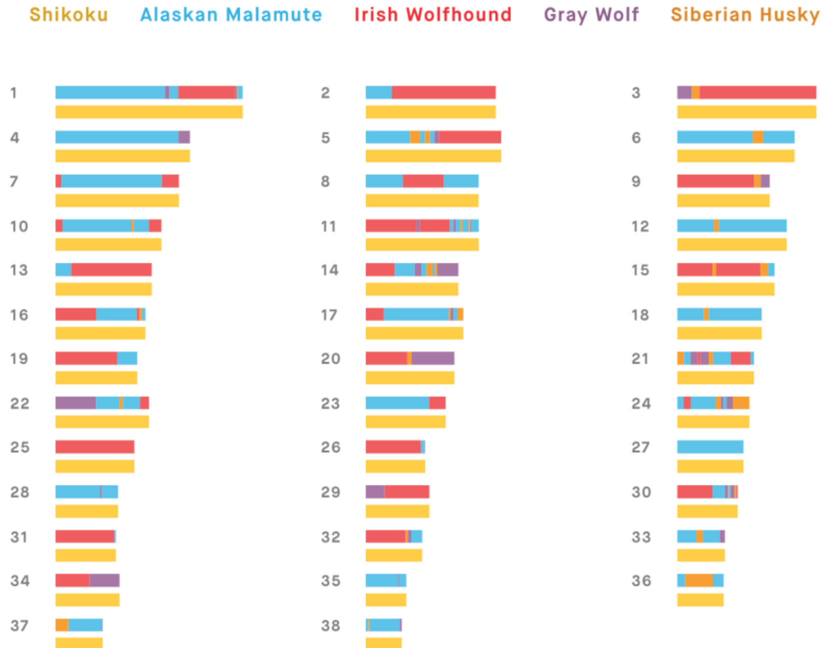


Figure 3: Average inbreeding coefficients across purebred dogs. Graph created by Carol Beuchat in 2016 from data collected by Johnson in 2017.

Many dog breeders are aware of the risks of inbreeding, and yet very little has been done to manage inbreeding within dog breeds. The discrepancy comes from the difference between pedigree and genetic COI. Most dog breeders rely on the extensive paper pedigree that tracks their dogs' ancestors to create pairings well under the recommended inbreeding cap. However, pedigree calculations are misleading for three reasons. One, a pedigree does not go back in time indefinitely, an assumption crucial to accurately predicting COI. Most pedigrees only go back anywhere from 5-20 generations. Two, pedigrees are filled with inaccuracies, whether intentional or accidental, parentage can be mistaken and create misleading COI calculations. Three, even if all the records went back to before the breed's foundation and also were accurate every step along the way, the pedigree COI still doesn't account for the variation of inheritance of genetic material. Pups do not inherit their grandparents' genes equally, leading to different COI calculations for pairings throughout generations. Figure 4 depicts the chromosome makeup of two full sibling crossbred littermate dogs. If either was bred back to their Irish Wolfhound great-grandparent, the resulting litter would likely have different genetic COI measurements even though the pairings would have equal pedigree COI calculations. For these reasons, it is important to track the genetic COI, the measurement of genetic diversity calculated by examining the structure of the dog's DNA.

Erza

Breed colors:



Thumos

Breed colors:

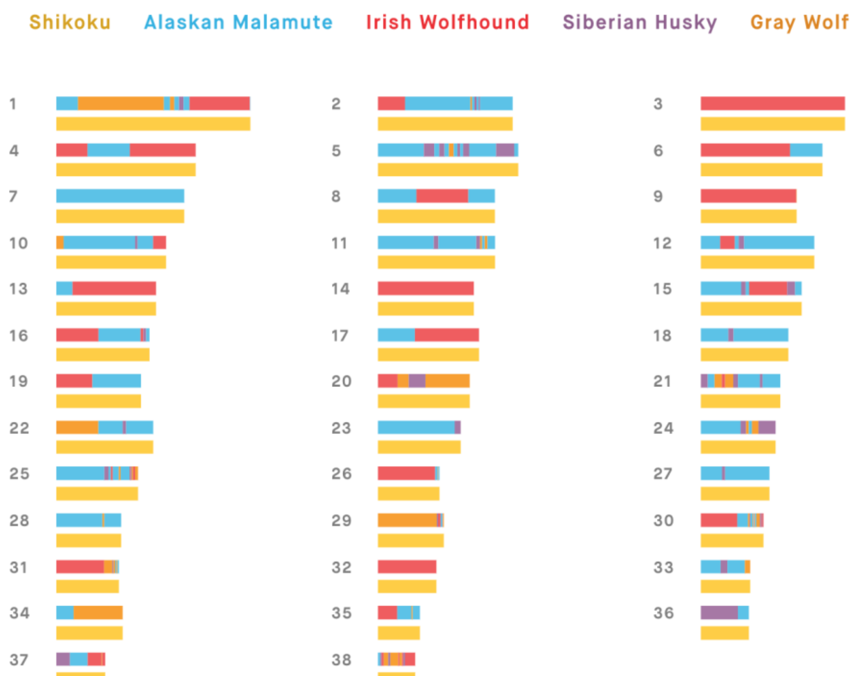


Figure 4: Chromosome makeup by breed for two full sibling crossbred dogs generated by Embark Vet (2019). Grandparent contributions represented by Alaskan Malamute, Irish Wolfhound, Siberian Husky and Grey Wolf grandparents and great-grandparents are not equally represented in both littermates. Note that the colors of Siberian Husky and Grey Wolf are switched in the graphs; this is because the colors were created based on descending breed content, and Thumos inherited more Grey Wolf than Siberian Husky.

Unfortunately the genetic COI in dogs does not have a universal measurement. Many companies have unique genetic COI calculations that are performed with different types of genetic data. This field is growing rapidly as more breeders and dog owners seek to understand their dog better through consumer genetic testing kits.

The modern breeding system works to decrease genetic diversity through highly selective reproduction, overrepresentation of popular sires, and reliance on pedigree coefficient of inbreeding calculations. High levels of inbreeding can be beneficial to maintaining and improving characteristics in purebred dogs, but high levels of inbreeding can lead to dead ends in selection, loss of historic DNA, and decreasing health. The dog breeding system should switch to genetic coefficient of inbreeding calculations, which are more representative of the qualities inherited through inbreeding. Dog registries should prioritize maintaining genetic diversity through limitations on popular sires and inclusion of a larger body of dogs into the breeding population that may have been excluded in favor of more popular dogs.

Chapter Two: The First Registries

The first dog show was held in 1856 in Newcastle, England, with only two breeds: pointers and setters. After that, dog show participation and interest grew rapidly, with the National Dog Show in Birmingham seeing hundreds of dogs, dozens of breeds and thousands of visitors by the end of the 1860s. In the following years, stud books were created, pronouncing individuals with good characteristics as “purebred”. This registration increased the value of their progeny, and the practice forever altered breeding practices in dogs (Ritvo, 1986).

Prior to the mid 1800s, dogs were certainly selectively bred for type and performance across the world, but the notion of “pure blood” or “conformation to the standard” did not play a role in breeding decisions. Instead, a breeder’s aesthetic choice and the dog’s performance played the biggest role in selecting breeding animals. These pre-Victorian breeding structures had a large part in creating the huge diversity of size, type, and temperaments seen across modern breeds. Most animals remained intact and many produced puppies. Puppies with unknown parentage or of crossed breeds were often still used for sporting or working and bred if they performed well.

As dog breeding became a popular hobby in the late 1800s, more organizations appeared around the world to track the ancestry of dogs in order to maintain purity and improve the appearance of the breed toward newly written standards (Flack, 2020). During this time, Charles Darwin’s On the Origin of Species (published in 1859) was fresh on the minds of Victorian dog breeders. The concept of selection for superior generations as described by Darwin led into the ideas of eugenics. The eugenics theory began as an idea that one could control reproduction to produce superior generations. Eugenics was a popular theory during the formation and early years of dog registries. The eugenic movement inspired emphasis on breeding “best to the best” and the perceived superiority of the pure blood. While before a good dog could prove itself through character, the modern dog could simply prove its superiority through its bloodline.

As the dog fancy grew, exotic types of dogs were imported from around the world and registered in England and America. The history, utility and type of the dog was not always represented accurately by the importers. This led to the division of breeds, where the registered breed diverged from the landrace or unpedigreed dog in its country of origin. Today, the rift can still be seen, where the country of origin believes the registered version less pure than their landrace population and vice versa. The Saluki dog exemplifies this case. The Saluki dogs that founded the European purebred Saluki did not fully represent the breed as they existed for hundreds if not thousands of years in their native lands of the Middle East, and the better or more pure bloodlines are still debated today (Duggan, 2009). The truth is more complicated: while pedigree dogs have a higher likelihood of an exclusionary lineage, landrace dogs are more likely to represent the variation within the breed that has existed for hundreds or thousands of years before registrations. The genetic signatures can be unique to the populations in both cases (Johnson, 2017).

In other cases, breeds were created from crossing dogs of many breeds to create a new breed, or recreate an extinct breed. The once extinct Irish Wolfhound of myths was historically recreated by Captain George Augustus Graham in the mid-late 1800’s by crossing a variety of dogs, from Great Danes to Deerhounds. He believed the gigantic hunting and war dogs depicted in historic texts lived on in these breeds and thus in his Irish Wolfhounds (Hogan & McAleenan, 1917). After a variety of crosses, he standardized the breed and soon after, the studbooks were closed. Counterintuitively, this breed created by crossing is also among those at the highest risk for lack of genetic diversity. The Irish Wolfhound is increasingly susceptible to early death, low fertility and inheritable diseases that correspond to their incredibly high genetic COI (Urfer, Gaillard, & Steiger, 2007). This is caused by the unique history of their creation from a small population and tight inbreeding to quickly gain certain characteristics.

The idea behind pure blood is not unfounded. Dog breeds display amazingly consistent physical and mental qualities in part due to the pedigree system and the close relatedness of the individuals within a breed. Traits that breed true are often fixed in a population through inbreeding. Although many dog breeders continue to value purity of blood above all else, it now appears that few dogs are as pure as they appear to be on paper. Registration breeding has not likely been without errors or forgeries, but now with genetic tools, it is even more apparent that cross breeding has occurred within many purebred dogs (Dreger et al., 2019).

Intentional crossing of breeds even outside the show dog world is largely abhorred. Even the most carefully planned cross will be scorned by dog fanciers. There are common concerns that any mixing will lead to unpredictability and unravel hundreds of years of careful pairing. However, just because a population is closed doesn’t mean it is fixed. There is room for regressing within the pure blood, and there is room for improvement using outside blood, or outcrossing.

In the mid 2010's, Jennifer Perry of Australia, a breeder of purebred English Mastiffs, became aware of the impacts of modern breeding practices on the welfare of her breed. One of her Mastiff pairings produced a litter of puppies that contained piebald spotted puppies, a color that was disqualifying for registration. Frustrated by the exclusion of purebred puppies based only on a color that is historically present in the breed population was not Perry's only concern with the modern breeding systems by the time she started her controversial project. The English Mastiff, she observed, had been bred to more and more extreme types over the years. These exaggerated qualities, including a heavier build, a shorter face, and deeper wrinkles not only failed to represent the powerful dogs that she saw depicted in historic paintings, but that these traits were increasingly linked to health problems. Perry also came to the conclusion that the gene pool of English Mastiffs was too small, and some of the fertility and lifespan decreases may be linked to the high inbreeding within the population. After research on genetic diversity and the history of her breed, she decided to outcross her pedigree mastiff to a champion racing greyhound stud (Flaim, 2017). Much like the LUA Dalmatians, her cross was incredibly controversial. Perry was outcast from her breed clubs and scorned for intentionally producing "mutts". Though her efforts to officialize the outcross with her breed club failed, she continued with the pairing, producing a big, healthy litter. Several of the pups were bred back to pure Mastiffs, both by Perry herself and another breeder in Holland, to regain the type and temperament they loved in the Mastiff breed. The second generation of dogs that are 75% Mastiff have regained a moderate Mastiff type and build (Figure 5). Perry has decided to suspend her project to limit the number of dogs she is responsible for, but her bloodline continues through other breeders. This Mastiff outcross project remains unsanctioned and largely abhorred by the Mastiff breeding community. Projects like Perry's demonstrate the quick return to type that can be observed in carefully planned outcrossing programs, even if the starting breeds are as dissimilar as a slight Greyhound and a massive Mastiff.

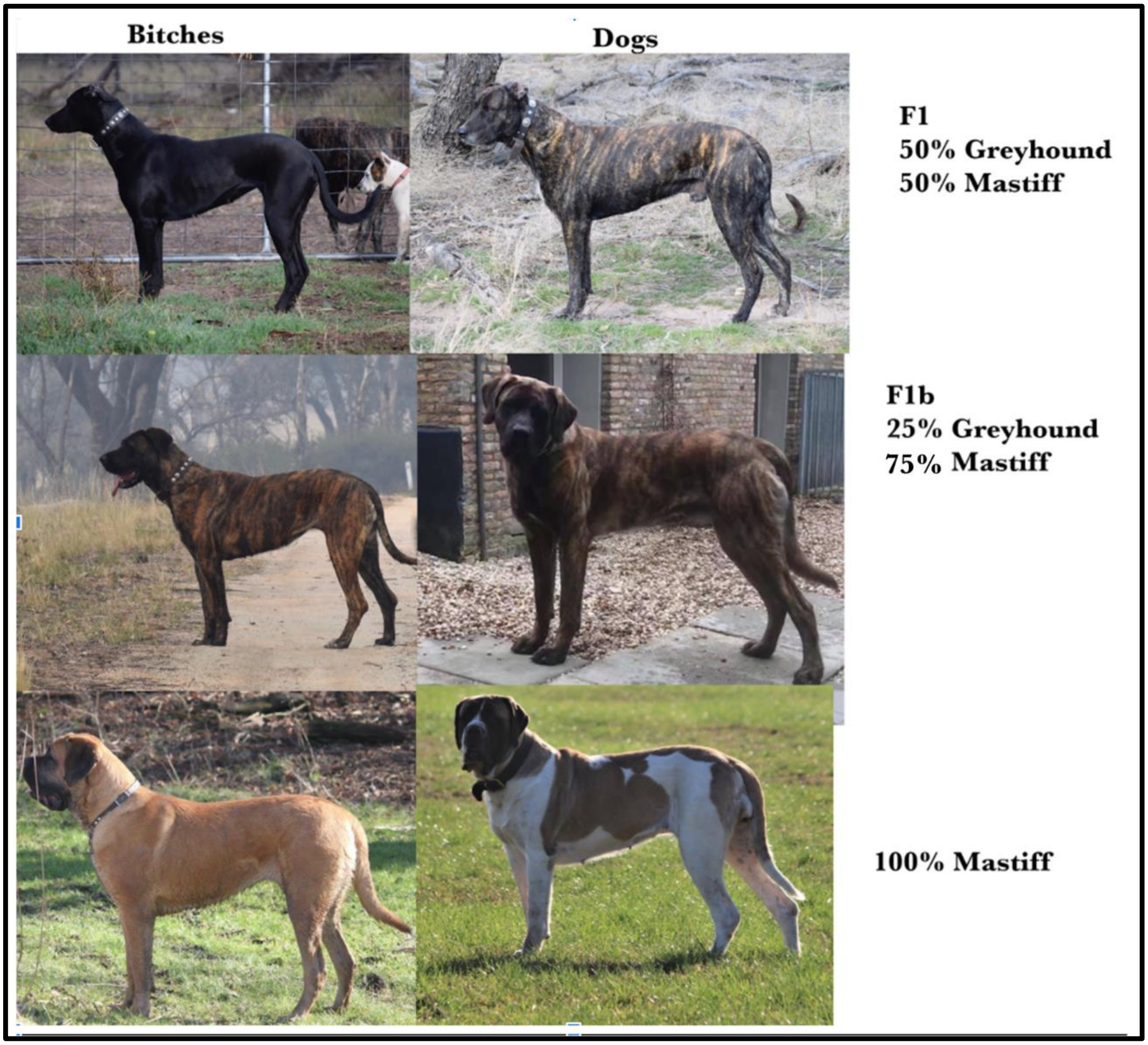


Figure 5: Photograph comparisons of dogs involved or produced in the Mastiff outcross project. Photographs courtesy of Jennifer Perry and Gaby Bemelen (2016-2020).

There is a prominent narrative in the dog breeding world that many dog breeds are ancient and pure. This notion is one justification for maintaining closed stud books, and it is not well supported by genetic studies. Although breeds certainly have unique genetic signatures, they are the result of inbreeding, not ancient purity. Based on genetic signatures, free roaming village dogs are also identifiable as different breeds (Johnson, 2017). Purebred dogs are a recent invention, not ancient nor pure. Dog registries and modern breeding practices were established long before the discovery of DNA, and have not changed markedly in response to the new science. There is less justification for maintaining pure blood at any cost when it is established that purity is a manufactured claim. The preservation of pure blood disservices the health and the history of dog breeds. The modern breeding system does not preserve histories when a color historically found in a breed population is unable to be registered as a purebred. The modern breeding system fails the health of dogs and their histories when the current trends deviate from the historic breed at the cost of health and soundness. A plan to rectify issues that cause premature death and suffering in dogs should not be controversial.

Chapter Three: The Rest of History

Although modern dog breeds originate in the late 1800's, dog types as variant as our modern breeds have been kept and bred for over a thousand years (Page, 2007). Separated by function and location, dog types developed through selective breeding practices and through chance, much like the modern dog. Herding and protecting livestock, hunting large and small game, and simple companionship are some of the tasks that dogs have excelled at for much of human history. The drives required for working closely with humans or independently have developed over a long time. In modern times, dogs are less frequently working and have become mostly companions, but the characteristics bred into them are still present to some capacity. One justification for the closed stud books is maintaining breed temperaments that made them suitable for the specific work they were bred for. This argument doesn’t take into account the huge amount of history where dogs were overwhelmingly used for their tasks but did not have close resemblance to the modern breeding system.

The dog has a universal appearance when left to breed free, in the case of many village or pariah dogs across the world. The dog is a small to medium size, often with short yellow-red fur, small upright or slightly flop ears, and round brown eyes. When dog breeds are mixed for just a few generations, no matter the starting breeds, these characteristics begin to define the new generations (Page, 2007). It is clear that intentional selective breeding by humans is the cause of all other types of dogs. There are claims in many breeds that certain characteristics came about due to the utility of that phenotype. For some breeds, this is likely true: However, for most breeds, the unique defining physical characteristics were simply appealing or unique and thus propagated, becoming defining characteristics of the breed for aesthetic reasons. These characteristics are often the result of just a few genes and sometimes a single gene, such as the case of wire hair or most dog coat colors (Ruvinsky & Sampson, 2001). Since most distinguishable characteristics in dog breeds are controlled by just a few genes, returning to “type” is not as difficult a process as believed. Within the open breeding used for centuries, dog types remained remarkably consistent through time and across continents, but contained variation that suggested frequency crossing. For example, both the heavy mastiff-type dog and the slender greyhound-type dog were used to pursue large game, and paintings often depict both types alongside a third, intermediate type, which suggests that the two were sometimes crossed without losing the lighter or heavier versions over the centuries (Figure 6). With the Mastiff cross program, the dogs in the paintings come to life. The Mastiff depicted in “Two Greyhounds and a Mastiff” painted in the 1700’s could as easily be a painting of Perry’s cross.

Figure 5: Two Greyhounds and a Mastiff, painted in the 1700’s (Gilpin).

Figure 6: A Dog in a Landscape, 17th century (Gilpin).

Although the pedigree system and closed stud books have imparted an impressive conformity to dogs within their breeds, these practices can not be fully attributed to the success of achieving consistency. Long before stud books, humans across the world relied on their dogs to perform breed-specific tasks, from herding livestock to coursing game (Page, 2007). Fewer modern dogs need to perform their historic duties and are instead companions in the home. The shift from working animals to pets came about around the same time as the closed pedigree systems. Some dog breeders believe that if a dog's parents show an aptitude for a task, the puppies will as well. Although this is generally true, there is still variation within each litter, with the capacity for some pups to be better at the task than parents and some pups to be worse (Wilsson & Sundgren, 1997). If generations of dogs are untested for aptitude, this aptitude can and will be lost. The only way dog breeds in history were maintained as working animals is selection against animals that did not meet expectations. In modern times, there is a sediment for breeders to maintain working characteristics in dog breeds, but these characteristics often do not complement pet dogs. The high energy and drive required for working sheep or pulling sleds hundreds of miles is not needed or desirable for a house pet. The development of dog sports that test and develop the behaviors and skills once required of dogs are one way that modern dog breeders balance the desire for historic preservation with creating animals that humans want to buy, own and live with.

Dog types have been historically maintained outside of the pureblood system for over a thousand years. Types and utility have not been degraded in a non-pure breeding system. Inbreeding is thus not required at the levels seen today for the benefits already begot from selection.

Improving The Modern Dog Breeding System to Preserve Histories and Improve Health

The modern breeding systems created by dog clubs and registries that originated in the Victorian times work to eliminate genetic diversity at the expense of health and preservation of dog breeds. I propose three fundamental shifts to the modern breeding system that will work to increase or maintain genetic diversity.

Redefine Dog Breeds: When the definition of a breed provided by the dog registries interferes with dog breeders' abilities to produce healthy dogs, such as the case in Dalmatians and English Mastiffs, the modern definition of a dog breed is flawed. Genetic diversity, once lost from a population, can not easily be regained without introducing genes from outside the population. A new breed definition should allow for outcrossing when the breed population fails to maintain a sustainable COI or when harmful mutations become fixed in the breed. Throughout history, dog breeds have seen frequent crossings, and all types can be reintroduced and maintained along with genetic diversity through careful breeding choices, exemplified by Perry's Mastiff outcross. The modern definition of a purebred dog does not accurately portray the history of many breeds. A new breed definition could open to include unpedigreed landrace dogs that represent the original breed founder's populations.

Increase Population Sizes: The intensely selective process by which dogs are eligible to reproduce creates pressure on the genetic diversity within a breed. The modern breeding systems must make a fundamental shift in the ways which dogs are selected for breeding. Overrepresentation of popular dogs and lines should be discouraged, as it can lead to the unintentional extinction of historic dog contributions or a fixation of the popular dog's negative traits. More dogs should remain intact and produce puppies to increase genetic diversity A larger population of breeding animals could allow for more selection without further decreasing the breeding population.

Use Genetic Tools: The methods used to evaluate breeding dogs should begin to measure and emphasize maintaining and improving genetic diversity. Genetic COI should be standardized and all breeds should have available genetic matchmaking tools to choose pairings. Genetic testing should allow the breeding of dogs who carry undesirable recessive mutations, so that their breed contributions are not lost at once.

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